BBC RD 1985/6

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REPORT

An investigation of Band II field strengths: The Northampton experiment

G.H.Taylor, B.A., Dip.E.E.

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THE BRITISH BROADCASTING CORPORATION

June, 1985

BBC RD 1985/6
UDC 621.317.328:621.3.029.62

AN INVESTIGATION OF BAND II FIELD STRENGTHS: THE NORTHAMPTON EXPERIMENT

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Summary

Field strength measurements of several transmitters received within a 10 km by 10 km square are reported. A total of some 24,000 measurements were made each receiving location being characterized by 240 field strength measurements.

The work forms part of a series of studies intended to improve the BBC's field strength prediction program and to form a contribution to CCIR Rec. 370 and Rep. 239.

The measurements were made at 10 metres and 4 metres above the ground and also with aerials mounted on a car roof.

A figure of 11 dB is suggested as the average height gain factor between reception with car roof whip and halo aerials, and two element aerials at 10 metres above ground.

Issued under the Authority of

M.E.B. Moffat

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

June, 1985
(RA-218)

It uses SI units in accordance with B.S. document PD 5686.

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1. Introduction

This report describes a series of v.h.f. field strength measurements made in Northampton. The intention was to collect a set of data against which various field strength prediction techniques could be evaluated. The data was also to be used to determine the increase of field strength with receiving aerial height (height gain).*

In general the work is expected to form part of a substantial review of v.h.f. field strength measurement which will be used to improve the accuracy of the BBC prediction program for low receiving aerial heights.[1] It is also hoped to make a contribution to CCIR Recommendation 370 and Report 239.

Northampton is a county town in the south-east Midlands of England. It was selected for the measurement programme because it is fairly typical medium sized town, and because signals can be received from a number of different v.h.f. broadcasting stations over different paths. Northampton also has its own VHF-FM broadcasting site which allowed data to be collected for short paths. In many respects the experiment followed lines adopted for a similar study at u.h.f. conducted at Guildford some years ago[2]. The measurements were made within a 10 km by 10 km square which contained most of the town including its centre, typical surburban residential areas and surrounding rural country areas.

2. Signals measured

Signals were measured from Band II broadcast transmitters at Northampton, Sutton Coldfield (near Birmingham), Oxford, Peterborough and Wrotham (near London). Oxford and Peterborough were radiating horizontally polarized signals, the other stations radiated mixed polarization.

Measurements were made for the following different receiving conditions:

a) Ten metres above ground level (a.g.l.) using a two element yagi aerial. This aerial could be rotated axially from horizontal to vertical to measure both the horizontally polarized h.p. and the vertically polarized (v.p.) components of mixed polarized transmissions. The arrangement is shown in Fig. 1.

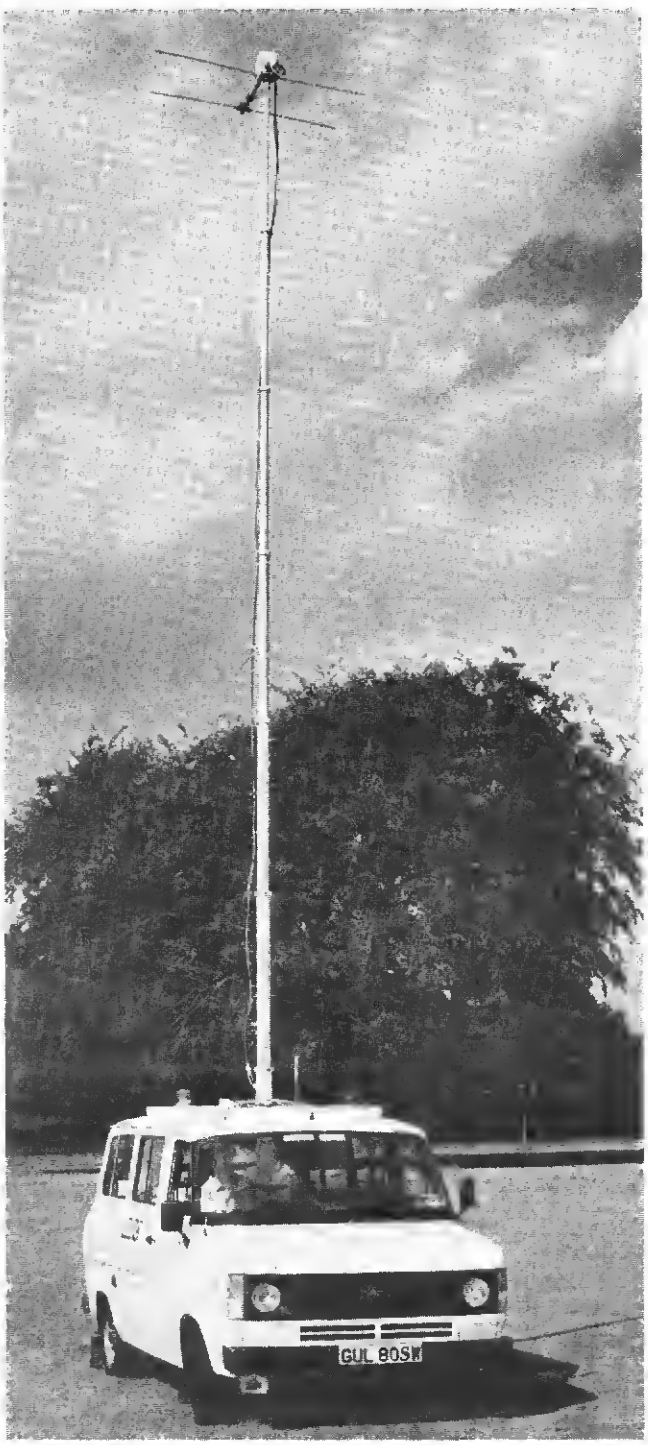

Fig. 1 — Field strength measuring vehicle with 10 metre mast and two-element yagi aerial.

*The author acknowledges the contributions of Messrs. D.S. Cox, A.S. Hall, J.Q. Endicott, J.A. Green and V.S. Huskisson in undertaking the field measurements for this study and for assistance in the analysis of the results.

b) As for a) but at 4 metres a.g.l.

c) Using a halo aerial mounted on a car roof at 2 metres a.g.l. (see Fig. 2). This aerial is horizontally polarized and omnidirectional.

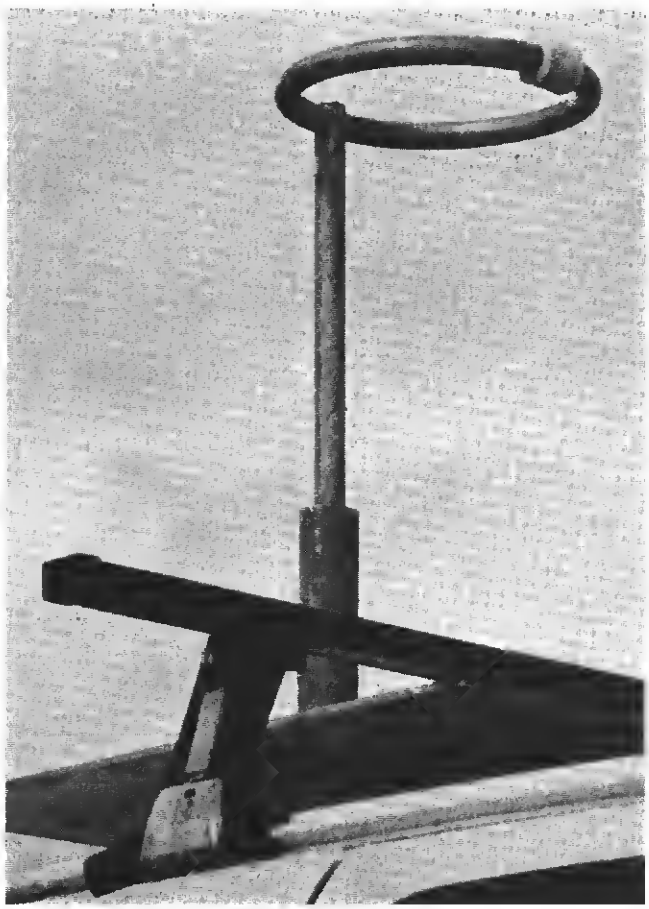

Fig. 2 — Halo aerial mounted on car roof.

d) Using a quarter wave whip aerial mounted in the centre of a car roof. This aerial is vertically polarized and omnidirectional. The height of the base of the whip was 1.6 metres above the ground.

The car roof aerials were calibrated against reference dipoles placed at the same heights in the absence of the car. The calibrations were repeated at a number of different locations and the results were averaged to minimise errors.

The receiver calibration accuracy is specified as ± 1 dB.

All the results quoted in this report refer to field strengths which have been adjusted to correspond to the field strengths which would have been received had the transmitter concerned been radiating an effective radiated power (e.r.p.) of 1 kW (1 kW h.p. + 1 kW v.p. for mixed polarized transmissions).

3. Measurement techniques

Measurements were made in each kilometre National Grid square within the 10 km by 10 km area selected for the experiment.

The location within each square at which measurements were made was selected as "The position nearest the centre of the south-west quarter of the one kilometre square at which it is practical to make the measurements".

At each of the locations thus selected, measurements were made at five separate points within a distance of between 10 and 20 metres for each of the different reception conditions. To provide extra data each location was classified as either urban, suburban, or rural. The exact six figure National Grid References and the classification of the locations at which measurements were made are listed in the Appendix.

Measuring techniques and equipment used involved a high level of operator involvement and it was not practical to automate the measuring system. It was felt important to minimise errors in transcribing the results and for this reason the results (for 10 metre and 4 metre measurements) were typed directly into a BBC Microcomputer system in the measuring vehicle, and were recorded on floppy discs.

This use of a computer allowed a limited amount of data validation to be carried out as the measurements were made. Additionally when measurements at all five points at each location had been completed, the computer was programmed to display all the results for that location together with means and standard deviations. This display enabled a rapid check to be made for "silly" input data at a stage when it was easy to repeat a measurement.

The computer was programmed in Basic, and the results were recorded on disc as one Basic "DATA" statement per point. This made data analysis simple: the DATA statements being added to the programs written to analyse them.

It was not practical to use the computer system in the car, but for compatibility the car measurements were fed into the computer later.

4. Results

4.1. Validity of five-point measurement technique

It is important to establish how representative is the average value of the measurements made at the five points at each location. An analysis was therefore carried out to determine the standard deviation of these five measurements.

Taking the Sutton Coldfield measurements as a typical example, the average of the standard deviations between each set of five points was only 1.3 dB for receiving heights of 10 metres, 2.0 dB at 4 metres, and 2.7 dB at car roof height. There was no significant difference with the polarization of the receiving aerial. It is evident therefore that the average value of each set of five field strength measurements is realistically representative of the field strength at that location.

4.2. Field strengths

The 10 metre field strengths measured at each location and normalized to a transmitted signal with an e.r.p. of 1 kW are shown on the maps (Figs. 3 - 7) which follow.

An unexplained discrepancy of 4 dB was found between the normalized field strengths of the h.p. and v.p. components received from Sutton Coldfield : h.p. being the stronger. Checks revealed that this difference was reasonably consistent throughout Northampton at all heights measured: it was also consistent along the bearing from Northampton to Sutton Coldfield. It was not the same on other bearings from Sutton Coldfield. The cause could not be located but could have been due to a ground reflection near the Sutton Coldfield site or due to a reflection from the old Sutton Coldfield mast which was still in position at the time of the tests.

The results shown in Fig. 3 are the average of the h.p. and v.p. field strengths and taking this into account there could be an error of ± 2 dB in these values due to the difference between h.p. and v.p. The height gain results will not have been affected.

Figs. 8 - 10 present the results in statistical terms and include the results for 4 metres a.g.l. and from the car roof aerials. Results for transmissions from the Northampton transmitter cannot be sensibly presented in this way because of the variation of distance.

The Wrotham measurements are incomplete because of interference: they must therefore be regarded as a biased sample.

4.3. Heights gains

The average height-gains for each transmission are listed in Table 1. These height gains are remarkably consistent between transmissions. There was no significant difference - at most 0.5 dB - between polarizations.

Table 1

	Height gain (dB)	
Transmission	4-10m a.g.l.	Car roof – 10m a.g.l.
Sutton Coldfield	7.5	11.3
Oxford	7.2	10.6
Peterborough	6.9	10.3
Northampton	7.4	12.1

It would seem sensible to adopt a value of 11 dB as typical of the height gain for Band II signals between car roof aerials and 10 metres above the ground.

4.4. Differences between urban, suburban, and rural areas.

Only three of the measured locations were classified as "urban"; comparisons were therefore attempted only between "rural" and "suburban".

4.4.1. Height gains

Fig. 11 compares the distributions of height gain variations of signals from Sutton Coldfield in rural and suburban areas.

These curves were typical and show little significant difference in height gain between these two types of area.

4.4.2. Scatter between measurements

The standard deviation of the five-point measurements was not significantly different in rural and suburban areas at 10 metres a.g.l. At car roof heights the scatter was greatest and its standard deviation was about 1 dB greater in suburban areas.

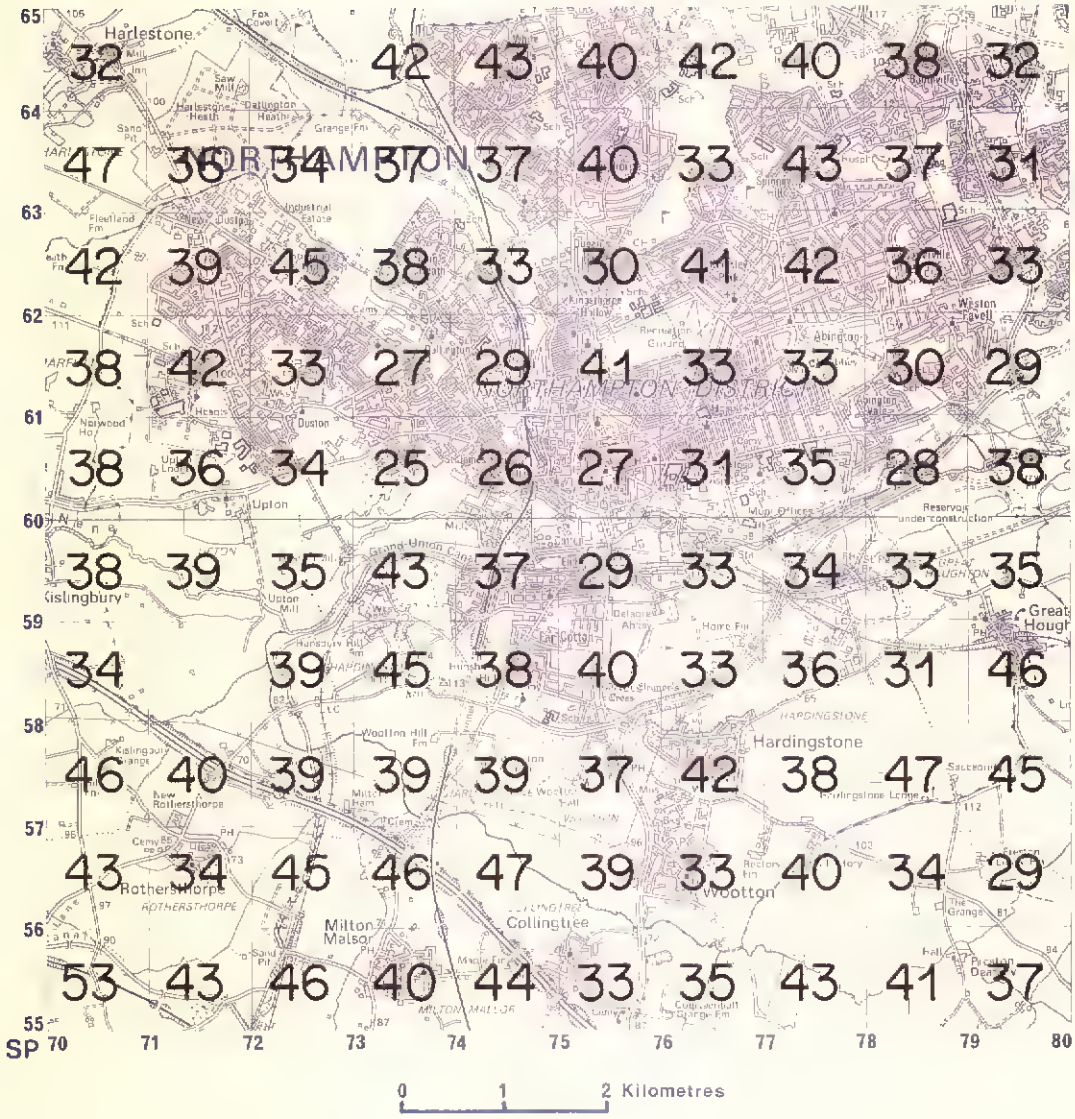

FIG. 3

Mean field strengths of Sutton Coldfield transmitter
10 metres a.g.l. — 3 frequencies h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Sutton Coldfield transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of Northampton. The numbers are the average of the h.p. and v.p. components of all three frequencies.

Sutton Coldfield transmitter parameters

NGR: SK 113 003
Site height: 169 metres a.o.d.
Mean aerial height: 200 metres a.g.l.
Polarization: Mixed
Frequencies measured: 88.3, 90.5, & 92.7 MHz

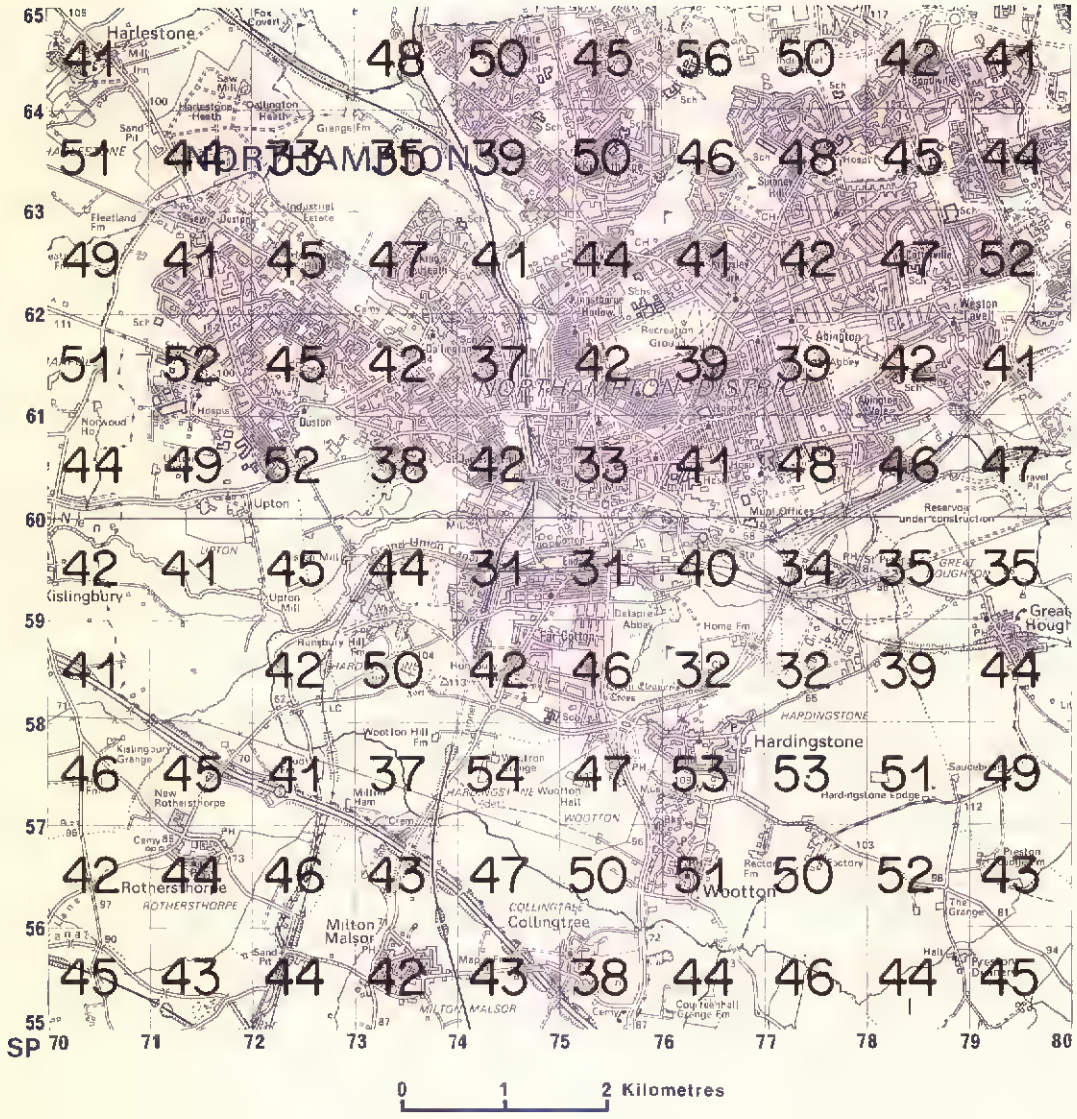

FIG. 4

Mean field strengths of Oxford transmitter
10 metres a.g.l. — 1 frequency h.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Oxford transmitter been 1 kW(h.p.) in the direction of Northampton.

Oxford transmitter parameters

NGR: SP 567 104
Site height: 130 metres a.o.d.
Mean aerial height: 140 metres a.g.l.
Polarization: Horizontal
Frequency measured 91.7 MHz

FIG. 5

Mean field strengths of Wrotham transmitter
10 metres a.g.l. — 1 frequency h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Wrotham transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of Northampton. Where possible the numbers are the average of the h.p. and v.p. components.

Because of interference, measurements could not be made at all locations and at some measurements could not be made on both polarizations. Note therefore that these results must be regarded as a biased sample.

Wrotham transmitter parameters

NGR: TQ 595 604
Site height: 219 metres a.o.d.
Mean aerial height: 150 metres a.g.l.
Polarization: Mixed
Frequency measured: 91.3 MHz

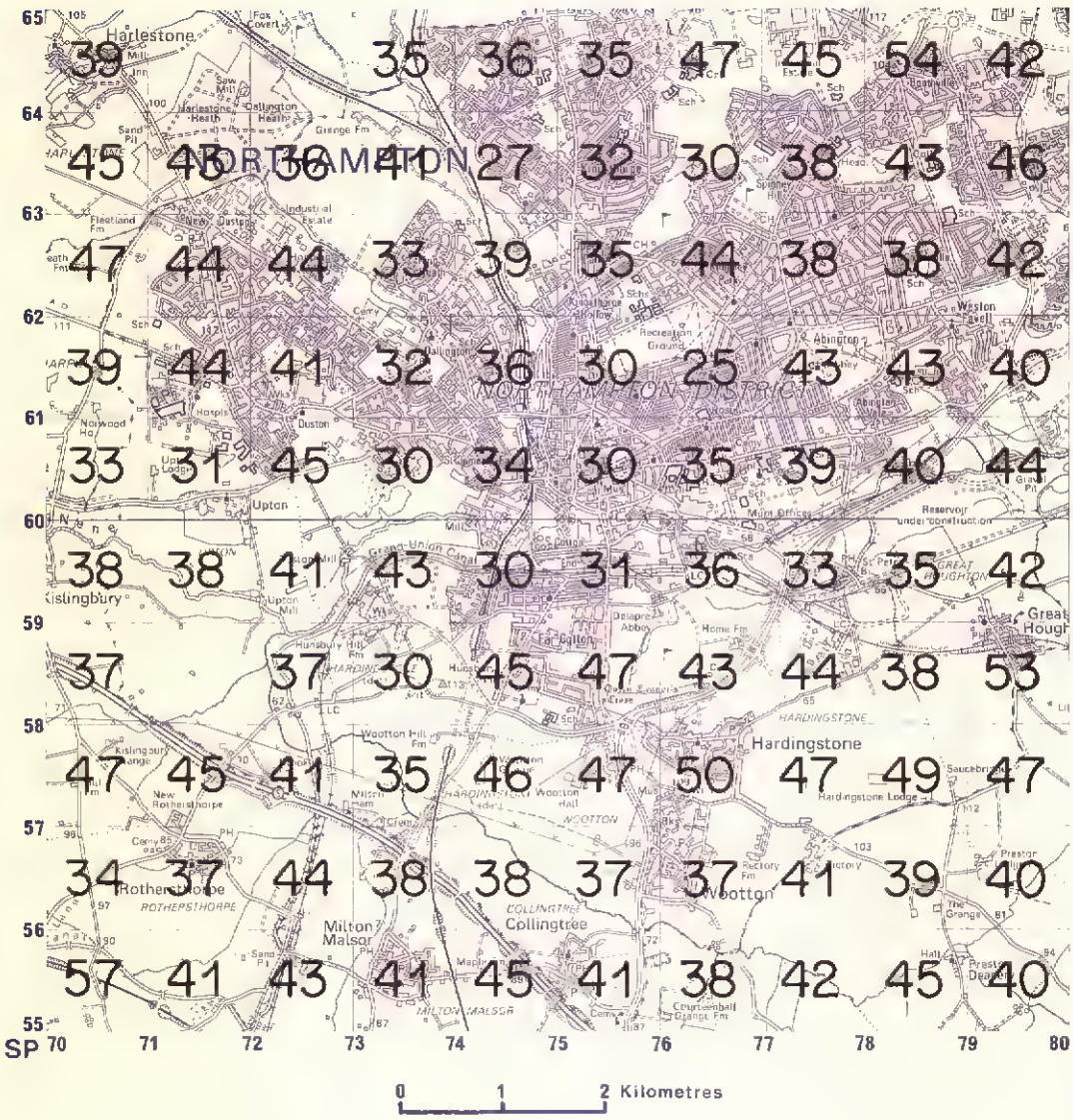

FIG. 6

Mean field strengths of Peterborough transmitter
10 metres a.g.l. — 1 frequency h.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Peterborough transmitter been 1 kW(h.p.) in the direction of Northampton.

Peterborough transmitter parameters

NGR: TL 127 913
Site height: 56 metres a.o.d.
Mean aerial height: 133 metres a.g.l.
Polarization: Horizontal
Frequency measured: 92.3 MHz

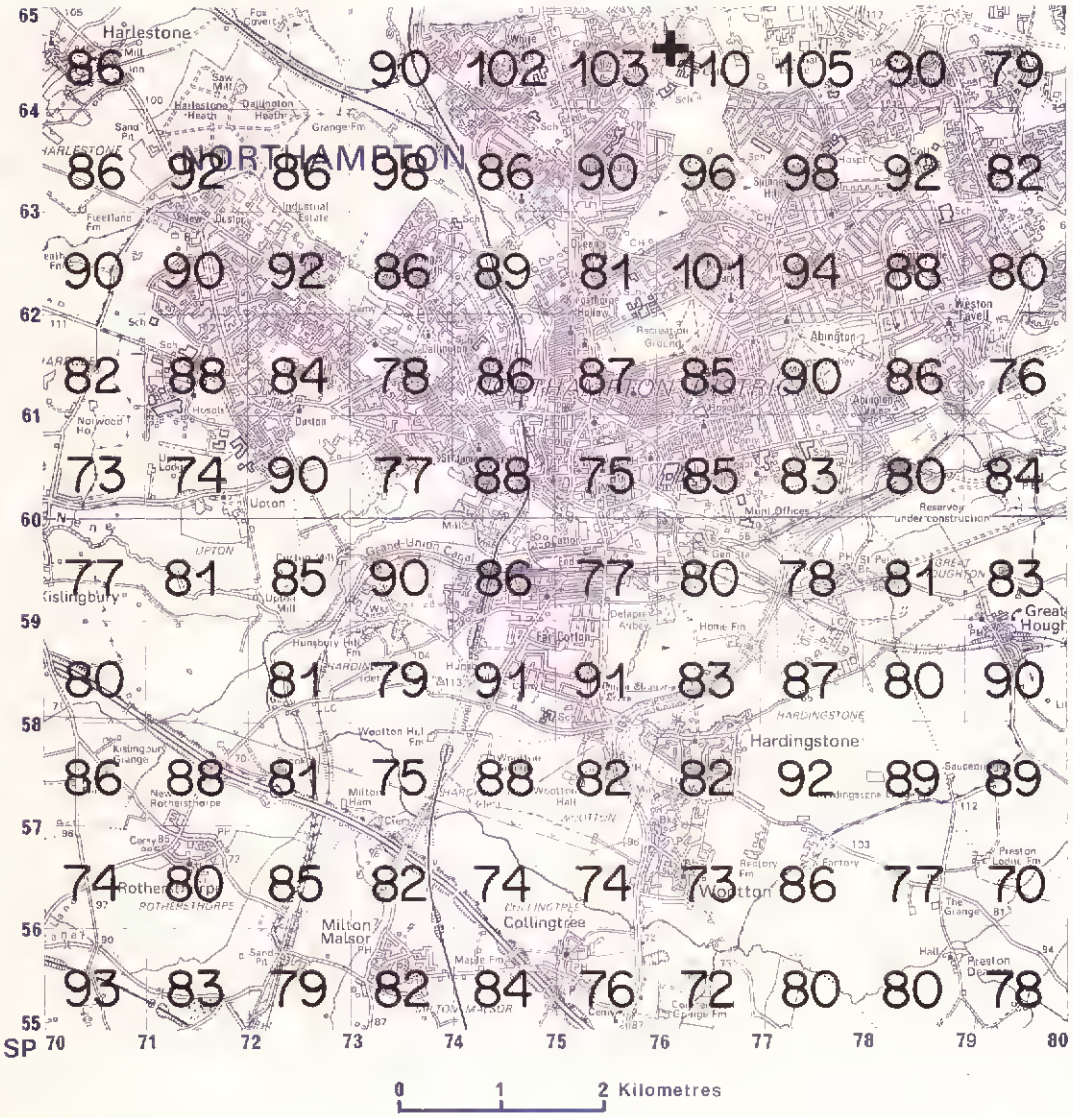

FIG. 7

Mean field strengths of Northampton transmitter
10 metres a.g.l. — 3 frequencies h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Northampton transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of the receiver. The numbers are the average of the h.p. and v.p. components of all three frequencies.

Northampton transmitter parameters

NGR: SP 761 647 (shown as ✚ on map).
Site Height: 128 metres a.o.d.
Mean aerial height: 23 metres a.g.l.
Polarization: Mixed
Frequencies measured: 88.9, 91.1, & 93.3 MHz

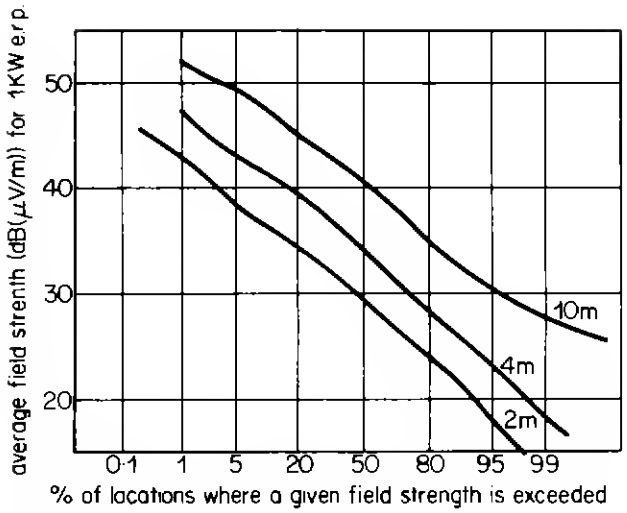

Fig. 8 — Field strength distribution of Sutton Coldfield transmissions in the Northampton area.

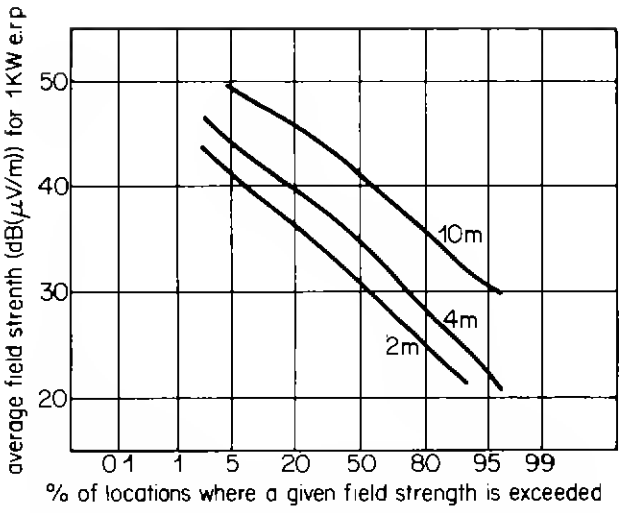

Fig. 10 — Field strength distribution of Peterborough transmissions in the Northampton area.

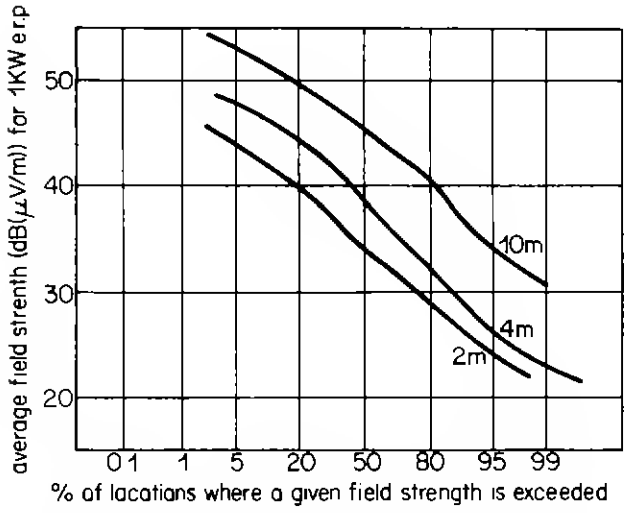

Fig. 9 — Field strength distribution of Oxford transmissions in the Northampton area.

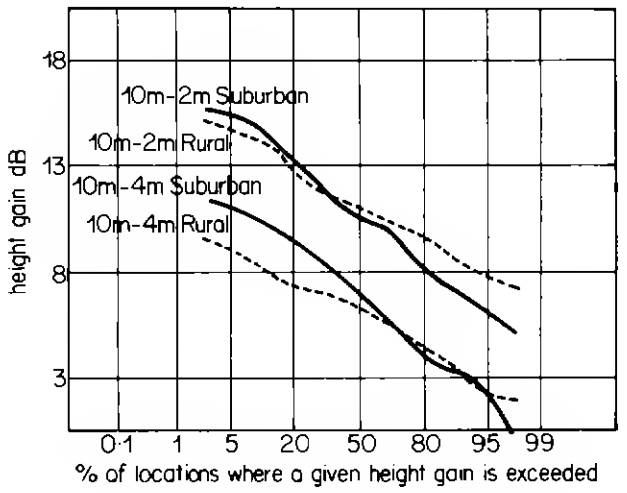

Fig. 11 — Rural and suburban height gains (Sutton Coldfield h.p.).

5. Further work

The results of this experiment are now being used in the improvement of the BBC computer prediction program. Further work to investigate the distribution of this type of measurement within 1 km squares is planned. A more detailed study of field strength variations at car aerial height is also in progress.

6. Conclusions

A set of data has been assembled against which prediction techniques can be tested. Height gain values derived from this data show that field strengths at 10 metres above the ground were on average 11 dB stronger than those measured at 2 m a.g.l. Differences between rural and suburban area measurements were small. Work is continuing.

7. References

1. CAUSEBROOK, J.H., TAIT, B. Computer programs for v.h.f. interference prediction using a terrain data bank. BBC Research Department Report No. 1978/13.

2. LEE, R.W., CAUSEBROOK, J.H. SANDELL, R.S. An investigation into the Prediction of Field Strength : 'The Guildford Experiment'. BBC Research Department Report No. 1970/26.

APPENDIX

List of six figure NGR's of locations at which measurements were made. The letter following each NGR refers to the classification of that location as, (R)ural, (S)uburban, or (U)rban.

SP701562 R
SP701583 R
SP701594 R
SP701601 R
SP702620 R
SP702645 R
SP703572 R
SP703612 R
SP703633 R
SP705550 R
SP711591 R
SP712567 S
SP712622 S
SP712633 R
SP713570 S
SP713601 R
SP714614 S
SP715550 R
SP721553 R
SP721579 R
SP722562 R
SP722612 S
SP722631 S
SP723581 R
SP723622 S
SP725605 S
SP727595 R
SP730578 R
SP731555 R
SP731584 R
SP732592 S
SP732612 S
SP735569 R
SP735605 S
SP735622 S
SP737631 S
SP737645 S
SP741611 S
SP742555 R
SP742593 S
SP742622 S
SP743602 S
SP743643 S
SP744583 U
SP745569 R
SP746632 S
SP748578 S
SP751602 U
SP752554 R
SP752574 R
SP752582 S
SP752592 S
SP752612 S
SP752631 S
SP753623 S
SP753642 S
SP757564 R
SP761593 S
SP762573 R
SP762611 U
SP762623 S
SP763562 R
SP763604 S
SP763631 S
SP764584 R
SP766558 R
SP767641 S
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SP771551 R
SP772582 R
SP772607 S
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SP772641 S
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SP773631 S
SP776591 S
SP779566 R
SP781606 S
SP781631 S
SP782588 S
SP782612 S
SP782621 S
SP782641 S
SP783572 R
SP783593 R
SP787550 R
SP787562 R
SP791592 R
SP791609 R
SP791613 S
SP792561 R
SP792573 R
SP792623 S
SP793631 S
SP793643 S
SP794551 R
SP794583 R

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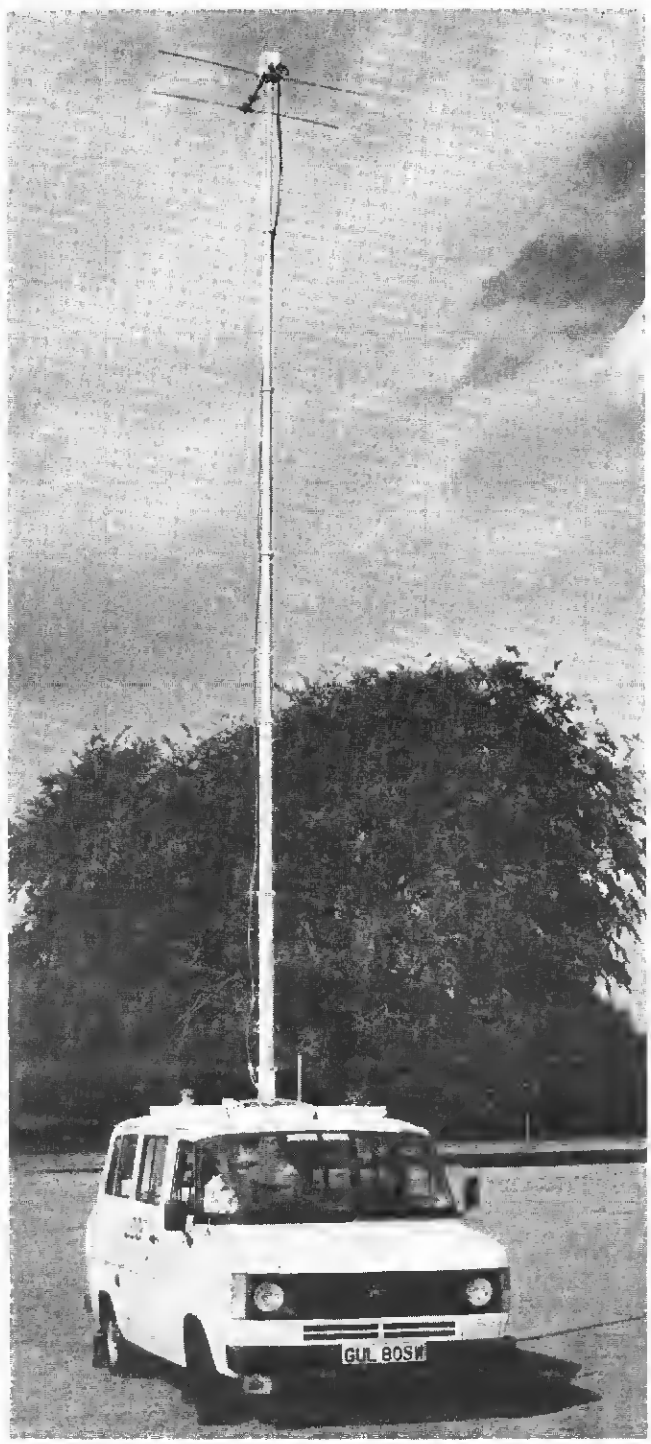

Fig. 1 — Field strength measuring vehicle with 10 metre mast and two-element yagi aerial.

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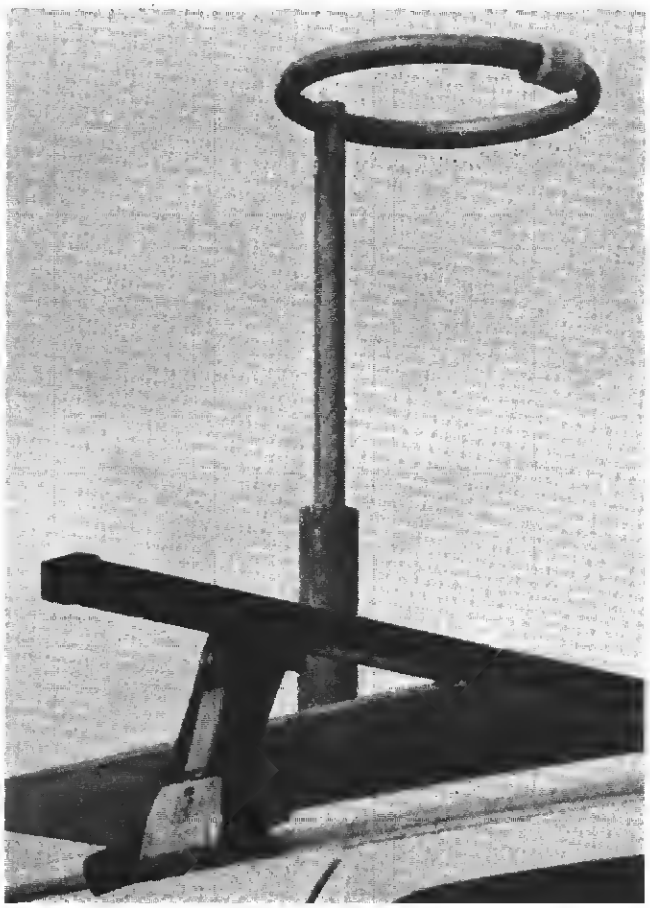

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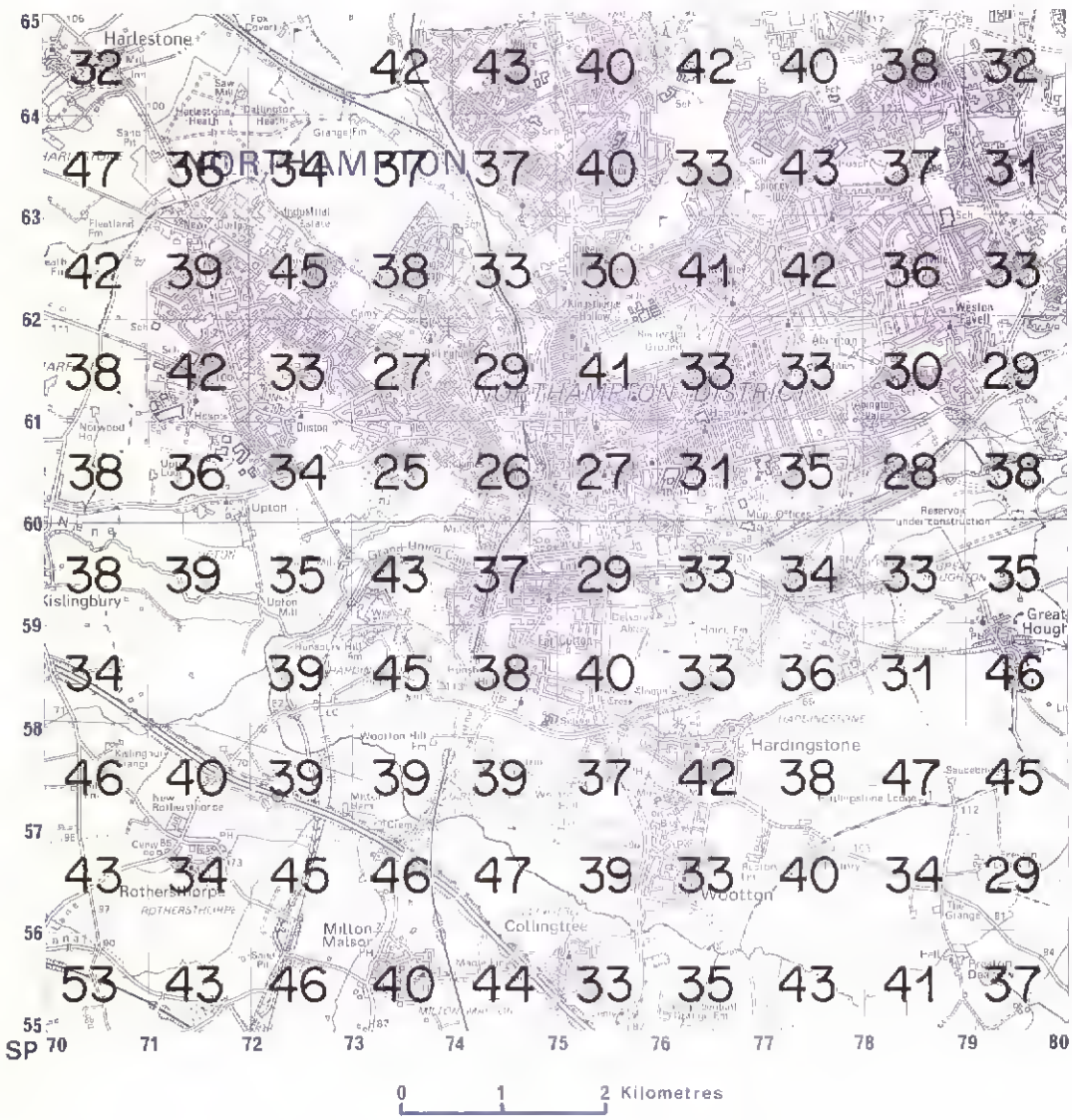

FIG. 3

Mean field strengths of Sutton Coldfield transmitter
10 metres a.g.l. – 3 frequencies h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Sutton Coldfield transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of Northampton. The numbers are the average of the h.p. and v.p. components of all three frequencies.

Sutton Coldfield transmitter parameters

NGR: SK 113 003
Site height: 169 metres a.o.d.
Mean aerial height: 200 metres a.g.l.
Polarization: Mixed
Frequencies measured: 88.3, 90.5, & 92.7 MHz

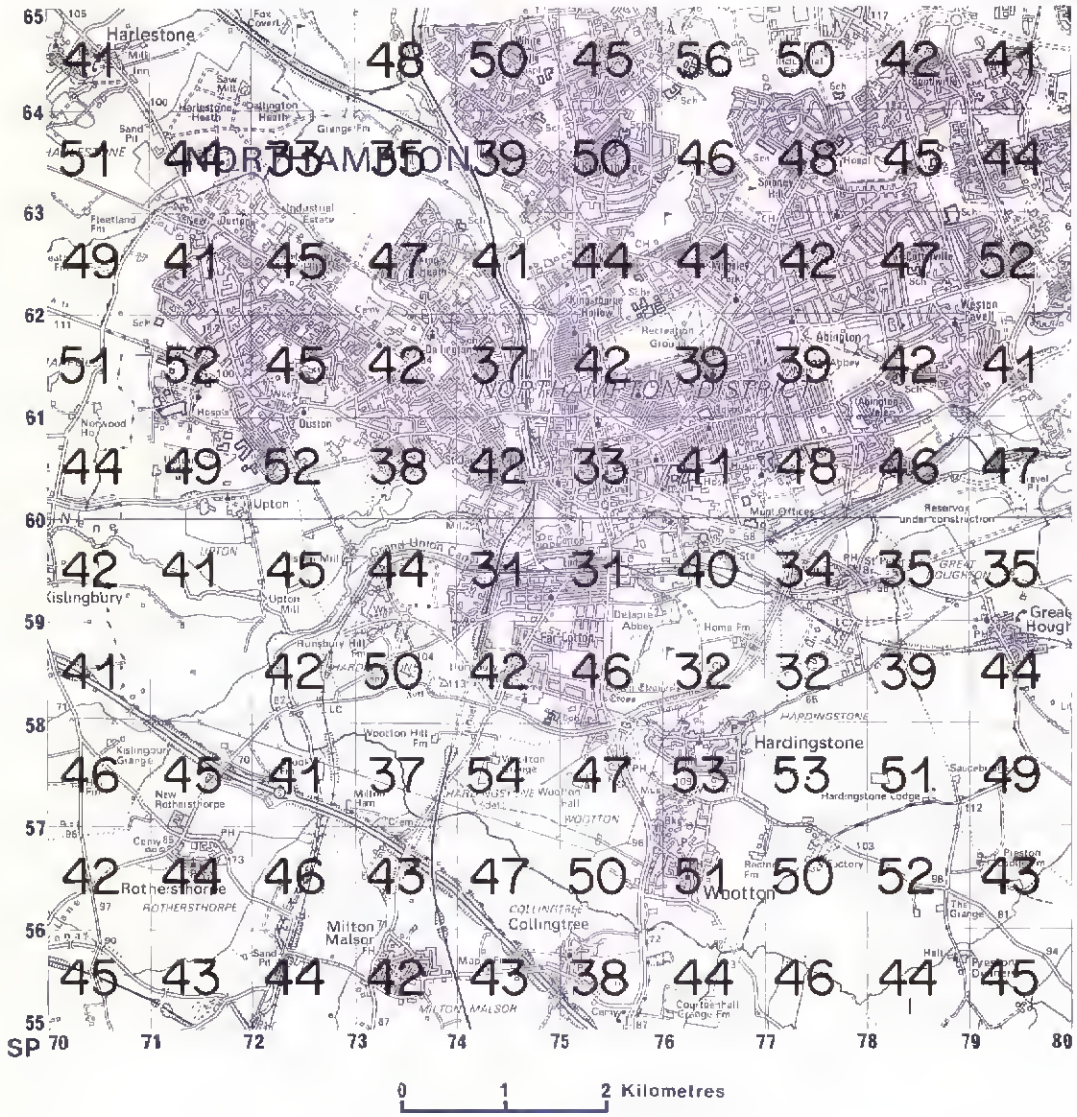

FIG. 4

Mean field strengths of Oxford transmitter
10 metres a.g.l. — 1 frequency h.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Oxford transmitter been 1 kW(h.p.) in the direction of Northampton.

Oxford transmitter parameters

NGR: SP 567 104
Site height: 130 metres a.o.d.
Mean aerial height: 140 metres a.g.l.
Polarization: Horizontal
Frequency measured 91.7 MHz

FIG. 5

Mean field strengths of Wrotham transmitter
10 metres a.g.l. — 1 frequency h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Wrotham transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of Northampton. Where possible the numbers are the average of the h.p. and v.p. components.

Because of interference, measurements could not be made at all locations and at some measurements could not be made on both polarizations. Note therefore that these results must be regarded as a biased sample.

Wrotham transmitter parameters

NGR: TQ 595 604
Site height: 219 metres a.o.d.
Mean aerial height: 150 metres a.g.l.
Polarization: Mixed
Frequency measured: 91.3 MHz

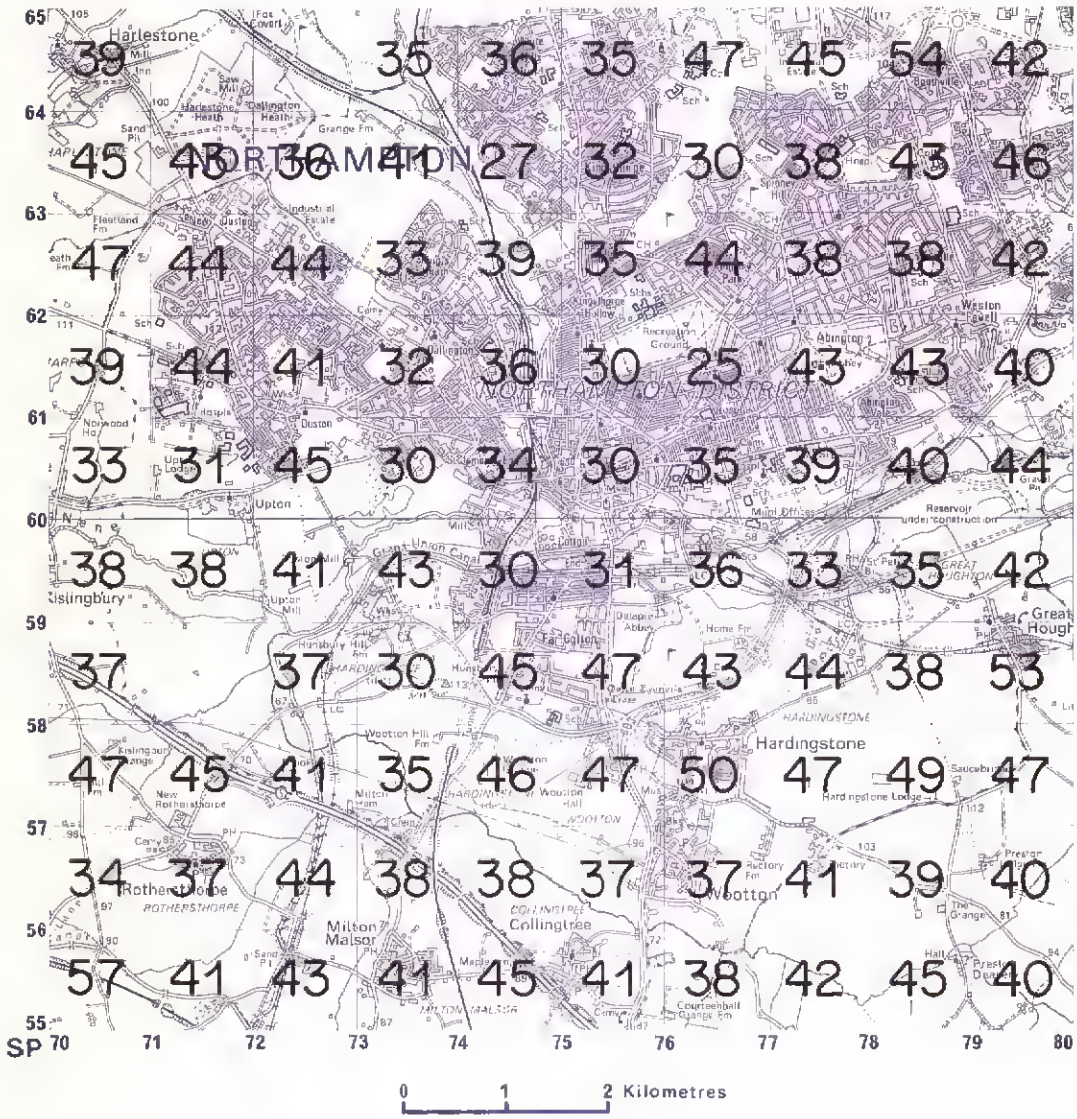

FIG. 6

Mean field strengths of Peterborough transmitter
10 metres a.g.l. — 1 frequency h.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Peterborough transmitter been 1 kW(h.p.) in the direction of Northampton.

Peterborough transmitter parameters

NGR: TL 127 913
Site height: 56 metres a.o.d.
Mean aerial height: 133 metres a.g.l.
Polarization: Horizontal
Frequency measured: 92.3 MHz

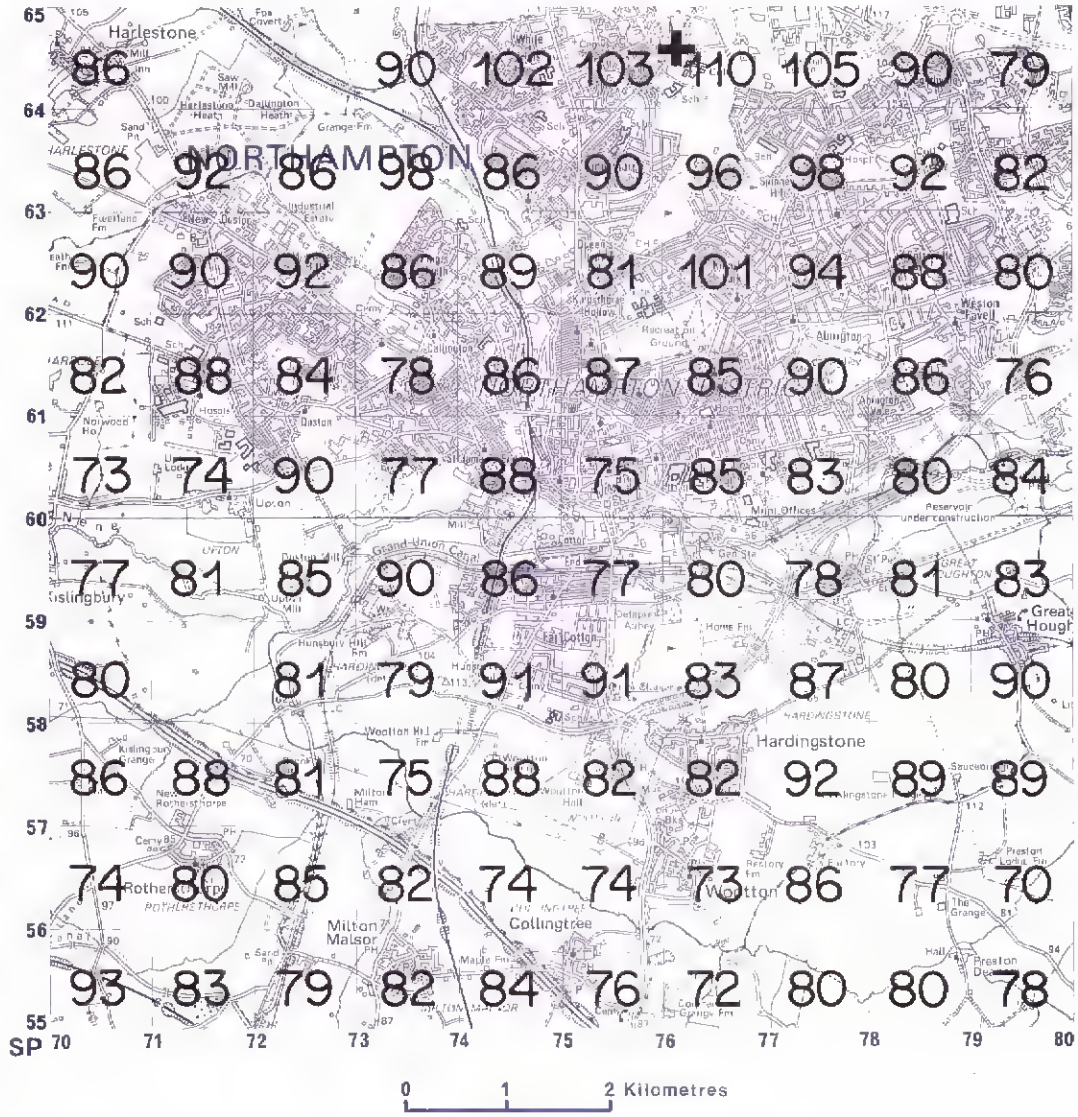

FIG. 7

Mean field strengths of Northampton transmitter
10 metres a.g.l. — 3 frequencies h.p. and v.p.

The number in each square represents the mean field strength in dB(μV/m) which would have been received had the e.r.p. of the Northampton transmitter been 1 kW(h.p.) + 1 kW(v.p.) in the direction of the receiver. The numbers are the average of the h.p. and v.p. components of all three frequencies.

Northampton transmitter parameters

NGR: SP 761 647 (shown as ✚ on map).
Site Height: 128 metres a.o.d.
Mean aerial height: 23 metres a.g.l.
Polarization: Mixed
Frequencies measured: 88.9, 91.1, & 93.3 MHz